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Effects of Mental Practice on Tank Gunnery Performance

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Human Resources Research Organization

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United States Army Research Institute for the Behavioral and Social Sciences

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The objectives of the present research were (a) to determine whether mental practice instruction enhances gunnery skill acquisition, and (b) to identify individual differences that relate to the use and effectiveness of mental practice. Three measures of individual differences were obtained: (a) the GT composite from the ASVAB, (b) Rotter's (1966) Internal/External (I/E) Scale, and (c) Betts' Questionnaire Upon Mental Imagery. Intact platoons of entry-level soldiers were assigned to either an experimental group that received mental practice instruction in addition to their normal gunnery training on the Institutional Conduct-of-Fire Trainer (I-COFT) or to a control group who received only normal I-COFT gunnery training. Students were pretested on their gunnery skills using a standardized I-COFT exercise. After 7 hours of training, all students were tested on the same standard exercise. Students also completed a questionnaire that assessed their use and evaluation of mental practice techniques. Results from the questionnaire indicated

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that soldiers in the control group mentally rehearsed gunnery without instruction to do so, although soldiers in the experimental group were more likely to use commonly prescribed mental practice techniques. Correlations in the control group indicated that soldiers high in intelligence or mental imaging ability responded much like soldiers in the experimental group; in contrast, the I/E scale did not predict the use of mental practice techniques. Results from the performance tests failed to show differences between experimental and control groups that could be attributed to mental practice. Two problems, however, make it difficult to reach conclusions about the effectiveness of mental practice in this experiment: (a) students in the control group spontaneously used mental practice techniques; and (b) the initial superiority of the experimental group in gunnery performance may have masked any gains due to mental practice.

Technical Report 873

Effects of Mental Practice on Tank Gunnery Practice

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FOREWORD

In 1984, the Army Research Institute for the Behavioral and Social Sciences asked the National Academy of Science to examine performance enhancement techniques that were presented with strong claims for effectiveness, and that were ". . . outside the mainstream of the human sciences" (Druckman & Swets, 1988, p. 1). Mental practice was one of the techniques that they identified as having potential for application to operational military tasks. This report presents the results from research that assessed the effects of these techniques on initial learning of armor gunnery skills.

This research is a part of the Army Research Institute for the Behavioral and Social Sciences (ARI) task entitled "Application of Technologies to Meet Armor Skills Training Needs." That task is performed under the auspices of ARI's Armor Research and Development Activity at Fort Knox, whose mission includes designing and executing human performance research in armor gunnery. The proponent for this research is the Training and Doctrine Command (TRADOC), and the user is the U.S. Army Armor Center (USAARMC) (Letter of Agreement with ARI entitled "Establishment of Training Technology Field Activity, Fort Knox, Kentucky," 4 November 1983). This project has been briefed to the Deputy Assistant Commandant of the Armor School, the Director of the Weapons Department, and the Commander and Staff of the 1st Armor One Station Unit Training (OSUT) Brigade. The design and execution of the research was closely coordinated with similar research efforts at the ARI Field Unit at Fort Benning.

The results from this research have direct bearing on the issues raised by the National Academy of Sciences. The methods and findings are also important to scientists concerned with applied research on mental practice effects.

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Dr. Robert Seidel (Chief, Automated Instructional Systems Technical Area) provided advice and materials regarding the use of relaxation techniques in mental rehearsal. Mr. Max W. Foster (Research Associate, HumRRO) coordinated data collection activities. Their contributions to this project are gratefully acknowledged.

THE EFFECTS OF MENTAL PRACTICE ON TANK GUNNERY PERFORMANCE

EXECUTIVE SUMMARY

Research Requirement:

Mental practice is defined as the symbolic rehearsal of a physical task in the absence of any gross muscular movement (Richardson, 1967). In its review of performance enhancement techniques, the National Academy of Sciences identified mental practice as one that has considerable empirical support and should therefore be evaluated in the context of operational military tasks (Druckman & Swets, 1988). In accordance with their recommendations, a mental practice program was developed for implementation and evaluation within the context of entry-level tank gunnery training. The specific objectives of the present research were (a) to determine how mental practice instruction affects soldiers' self-reports of mental rehearsal activities; (b) to determine the extent to which a mental practice program enhances gunnery skill acquisition; and (c) to identify individual differences that predict which students would use these techniques effectively, and which would benefit most from mental practice training.

Procedure:

The participants in the experiment were 90 soldiers undergoing Basic Armor Training at Fort Knox, Kentucky. The experiment was conducted during the soldiers' second week of training on the Institutional Conduct-of-Fire Trainer (I-COFT). Three measures of individual differences were obtained from all students: (a) the General Technical (GT) component of the Armed Forces Vocational Aptitude Battery, (b) Rotter's (1966) Internal-External (I/E) Locus of Control Scale, and (c) Sheehan's (1967) shortened version of Betts' Questionnaire Upon Mental Imagery (QMI). Intact platoons of entry-level soldiers were assigned to either an experimental group that received mental practice instruction in addition to their normal gunnery training or to a control group that received only normal gunnery training. Students were pretested on their gunnery skills on the I-COFT using a standardized exercise. During the final 7 hours of I-COFT training, experimental students were instructed to use mental practice techniques as an adjunct to gunnery training. Finally, all students were post-tested on the I-COFT using the same standard exercise used at the pretest. Immediately after the posttest, all students also completed a questionnaire designed to assess the quantity and quality of their mental practice experiences and their subjective impression of the effectiveness of mental practice techniques.

Findings:

Results from the questionnaire administered after the posttest indicated that soldiers in the control group spontaneously mentally rehearsed gunnery without instruction to do so, although soldiers in the experimental group were more likely to use mental practice techniques that were congruent with instructions. Correlations in the control group indicated that soldiers high in general ability (as indicated by GT) or high in mental imaging ability (as indicated by the QMI) responded much like soldiers in the experimental group. The I/E scale did not predict the use of mental practice techniques.

Results from the I-COFT performance tests failed to show differences between experimental and control groups that could be attributed to mental practice. Two problems, however, make it difficult to reach conclusions about the effectiveness (or ineffectiveness) of mental practice: (a) Results from the questionnaire suggested students in the control group were using mental practice techniques; and (b) performance of the experimental group was initially superior to that of the control group, which may have masked any gains due to mental practice.

Utilization of Findings:

The present research represented an initial attempt to implement mental practice in armor gunnery training. As such, it directly addresses questions about a performance enhancement technique raised by the National Academy of Sciences. The results also suggest new research topics for future research on mental practice, such as the spontaneous use of mental rehearsal.

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THE EFFECTS OF MENTAL PRACTICE ON TANK GUNNERY PERFORMANCE

Introduction

In 1985, a committee formed by the National Academy of Sciences and sponsored by the U.S. Army Research Institute examined performance enhancement techniques that were presented with strong claims for effectiveness and that were developed "outside the mainstream of the human sciences" (Druckman & Swets, 1988, p. 1). Mental practice was one of these techniques that the committee examined in detail. Mental practice has been defined as "... the symbolic rehearsal of a physical activity in the absence of any gross muscular movements" (Richardson, 1967, p. 95). The committee reviewed the literature on mental practice and concluded that mental practice improved performance on a variety of tasks. On the basis of these positive findings, the committee concluded that evaluation studies should be performed to assess the effects of mental practice on operational military tasks.

The present research was designed to assess the potential of mental practice for improving armor gunnery performance. Entry-level armor training provides an appropriate operational context for such an evaluation. Much of gunnery training for these soldiers is concentrated in two weeks on the Institutional-Conduct of Fire Trainer (I-COFT). Due to temporary shortages in I-COFTs and in qualified instructors, students experience periods where they cannot actively practice gunnery in the trainer. Mental practice may provide a useful activity for soldiers to perform during these down periods.

Research Background

Reviews of the mental practice research literature (e.g., Richardson [1967]; Corbin [1972]; Weinberg [1982]; and Feltz, Landers, and Becker [1988]) have identified some key factors that control mental practice effectiveness and potentially impact its application to tank gunnery. Specific factors and their implications for the present research are discussed in the following paragraphs. In addition to these specific factors, a general methodological shortcoming was noted in this literature: Most studies have focused on actual performance with no attempt to systematically measure the covert processes that underlie mental rehearsal. A central objective of the present study is to examine self-reports of mental rehearsal as well as actual performance. The purpose of looking at both types of data is to better pinpoint the locus of mental practice effects.

A variety of techniques have been used to mentally practice physical tasks. Although no particular technique has been established as universally superior in all situations, Singer (1972) found mental practice sessions that attempt to rigidly control the learner's thought processes inhibit his/her ability to conceptualize the task. He warned against requiring the learner to think along as the instructor reads the description because such passive learning does not allow the learner to concentrate on particular aspects of the performance. In a similar vein, Weinberg (1982) found that the greatest performance gains occur when subjects get a clear, vivid, and controllable image of actually performing the task themselves. Weinberg also concluded that the effects of mental rehearsal can be enhanced by the incorporation of systematic relaxation techniques, which theoretically reduce performance stress and increase imagery. Each of these specific techniques was incorporated into the present program for mentally practicing gunnery.

Given an appropriate method, it would be useful to identify individual difference factors that may facilitate or inhibit the effectiveness of mental practice. These factors also may be important in determining whether soldiers who are not given instructions to mentally rehearse actually do so spontaneously. One relevant individual difference is intelligence. Corbin (1972) hypothesized that "...more intelligent performers would benefit most from [mental practice] because of greater abilities in abstract thinking" (p. 110). However, results from Corbin's review of the mental practice literature and that of Richardson (1967) showed only meager support for this expectation: They identified six studies that addressed the relationship of intelligence and mental practice, but only one of these (Perry, 1935) indicated a significant positive relationship between intelligence and performance after mental practice. It should be noted that the focus of these studies was on performance of students under experimental conditions, i.e., with instructions to mentally practice. In contrast, the present study examined these relationships in control as well as in experimental groups to determine whether intelligent soldiers mentally practice gunnery spontaneously, i.e., without specific instructions.

Another relevant individual difference is the ability to image. Many studies have found that the greatest performance gains occur when subjects produce vivid, controlled images (Weinberg, 1982). For instance, Start and Richardson (1964) showed that ability to image was significantly related to the effective use of mental practice. On the other hand, others failed to show this relationship (White, Ashton, & Lewis, 1979; Singer, 1972). Despite these failures to find a relationship, imaging ability should logically be a factor affecting individual differences in mental practice. In that regard, the Betts' QMI Vividness of Imagery Scale (1909) is one of the most widely used and psychometrically sound measures of imagery vividness. The original 150-item inventory was shortened by Sheehan (1967), who found correlations in excess of .90 between the original and his shorter (35-item) version. This shortened form of the QMI was used in the present study to determine the relationship between individual differences in imaging ability and the effectiveness of mental practice techniques.

Motivational differences have been largely ignored in the mental practice literature. It seems probable that individuals who are highly motivated to learn are more likely to use mental practice in the acquisition and practice of skills. Rotter's (1966) Internal-External (I/E) Locus of Control Scale is correlated with achievement and self-responsibility in achievement situations. Scores from the bipolar I/E scale measure the degree to which individuals perceive contingencies or independence between their behavior and subsequent events. Those scoring on the internal end of the I/E scale perceive themselves as being in control of these contingencies and should therefore engage in behaviors such as mental practice that are perceived as effective in improving performance. In contrast, those on the external end of the scale perceive themselves as having little control over their fate and should be less likely to mentally rehearse. Because of these clear predictions, the I/E scale was used in the present research to investigate the effects of motivational differences on mental practice.

Research Objectives

The overall goal of the present research effort was to develop, try out, and evaluate a mental practice training program that can be used to increase the effectiveness of entry-level gunnery training. The specific objectives of the present research were threefold: (a) to determine how mental practice instruction affects soldier's self-reports of mental rehearsal activities, (b) to determine the extent to which this instruction enhances the learning of gunnery skills on I-COFT, and (c) to identify individual differences that can be used to predict which students spontaneously use this technique, and which students would benefit most from mental rehearsal training.

Method

Research Design and Participants

The design of the study differed from the typical research design for studying mental practice as described by Feltz, Landers, and Becker (1988). Commonly, such designs compare four sets of conditions formed by a factorial combination of mental practice vs. no mental practice and physical practice vs. no physical practice. The present study addressed the utility of mental practice as an adjunct to physical practice. Thus, only two of the four conditions were relevant to this question: physical practice plus mental practice vs. physical practice alone.

Participants in the present research project were 90 entry-level soldiers from a One Station Unit Training (OSUT) company undergoing 19K Basic Armor Training (BAT) at Fort Knox, KY. To facilitate administration of experimental treatments and to preclude contamination of those treatments across groups, three intact platoons were assigned to one of two conditions. One of the platoons (n = 29) was assigned to the control condition that received no mental practice instruction. The two remaining platoons (ns = 31 and 30) were assigned to the experimental group who received training in mental practice procedures. Originally, the two platoons assigned to the experimental condition were to be differentiated on the basis of where mental rehearsal techniques were to be administered: either in the presence of appropriate stimuli (i.e., the gunnery sights and controls) or outside of that context. The purpose was to determine the effectiveness of visual prompts on mental rehearsal. However, prior to starting the experiment, it became clear that logistic problems related to getting soldiers in and out of that context could not be overcome. Consequently, this distinction was abandoned and both platoons were treated identically, i.e., they received instructions to mentally practice gunnery in the context of training stimuli.

Gunnery Training

The mental practice program was implemented in the context of training on the M1 I-COFT, which is a high-fidelity, computer-based simulator for training tank gunnery skills. In addition to being a primary medium for training gunnery skills in BAT, the I-COFT has built-in features for measuring various aspects of tank gunnery performance. Soldiers were trained and tested in Week 9 of their 14-week training cycle. Prior to this point in training, soldiers had received approximately 12 hours of I-COFT training to learn prerequisite skills such as positioning switches, identifying targets, and manipulating the gunner's control handles. During the seven remaining hours of I-COFT training in Week 9, the soldiers integrate these skills by practicing gunnery engagements in whole-task fashion. Groups of related I-COFT engagements are organized into training exercises, each of which last approximately 15-20 mins. The exercises are arranged into three blocks of training, each block lasting either two or three hours.

At the time of the experiment, the I-COFT training facility had 24 training simulators and 22 instructor/operators (I/Os) allocated to Armor BAT. Because platoons in BAT are trained as intact units, about half of the soldiers in a normal-sized platoon (about 30 soldiers) were required to share a single I/O and I-COFT with another student. The shortage of I-COFTs and I/Os had two implications for the present research. First, some of the soldiers received less than seven hours of training during the experimental sessions. For that reason, the number of exercises completed by each soldier during the last seven hours of I-COFT was recorded. Second, during training soldiers had "down" periods where they received no physical practice on I-COFT. During these down periods, each soldier was required to observe the performance of his partner from the I/O station. This period of inactivity provided the opportunity for students in the experimental group to use mental practice procedures.

Individual Difference Measures

Data from all soldiers were collected on three measures of individual differences that are potentially related to the use and effectiveness of mental practice techniques. The first measure was the soldier's General Technical (GT) score from the Armed Forces Vocational Aptitude Battery (ASVAB), which was retrieved from unit records. GT consists of three ASVAB components (Word Knowledge, Paragraph Comprehension, and Arithmetic Reasoning) and is commonly considered to be a measure of "general ability," the central construct measured in standard intelligence tests. The second measure was the I/E Locus of Control Scale, a widely used individual difference measure for determining the degree to which persons perceive outcomes as being dependent upon their behavior. The version of the I/E inventory used here was the 29-item, two-alternative, forced choice test as described by Rotter (1966). The third measure was the Betts' Questionnaire Upon Mental Imagery (QMI). The version of the QMI used in the present study was a modified 35-item test developed by Sheehan (1967) wherein respondents rate imagery experiences with five items pertaining to each of the seven sensory modalities. An overall QMI score was obtained by computing the average rating across each of the seven modalities.

Procedure

Each component of the procedure is described in the following paragraphs in the chronological order that they occurred. The sequencing of the treatment (mental rehearsal instructions) and the pretest deserves particular comment. There were two aspects to the experimental treatment: (a) the mental rehearsal briefing that occurred prior to I-COFT training, and (b) mental rehearsal reminders that were inserted immediately prior to each of the blocks of training. The function of the briefing was to introduce mental rehearsal concepts to the soldiers, whereas the function of the reminders was to actually get the soldiers to use the concepts to improve performance. The pretest of gunnery skills on I-COFT was originally scheduled to precede both aspects of the treatment so that initial performance would be uncontaminated by mental rehearsal effects. However, the use of the I-COFT training facility was constrained during Week 9 such that the period of time that was available between the pretest and training was severely limited. There was not enough time to present the lengthy mental rehearsal briefing at that point, but there was sufficient time to insert the relatively short reminder sessions between the pretest and the start of training. Consequently, the mental rehearsal briefing had to be rescheduled to occur prior to I-COFT pretesting. This departure from standard design logic was tolerated because it was expected that the positive effects of mental rehearsal (if any) would be attained primarily from the reminders rather than from the briefing.

Individual difference measures. Immediately prior to beginning the I-COFT training scheduled for Week 9, each of the three platoons were administered two individual difference measures. (Individual GT scores were obtained from company records.) As a preface to this testing session, each platoon was told that it was chosen to participate in a research project to "assess the relationship between mental processing and tank gunnery performance." In this context, they were told that the paper-and-pencil tests provided measures of those processes. Following this brief introduction, soldiers in each platoon were administered, in order, the Rotter's I/E scale and the Betts' QMI scale. Specific test instructions (taken literally from the published tests) were printed on each soldier's copy of the test. The soldiers were able to complete both tests in approximately 25 mins.

Mental practice briefing. Immediately after completing paper-and-pencil tests, the two platoons in the experimental group received a prerecorded briefing on mental practice techniques. The script and accompanying slides for the briefing are attached at Appendix A. The briefing was divided into three parts whose purposes were (a) to define mental practice and describe its application to armor gunnery training; (b) to define and practice systematic relaxation for enhancing mental practice techniques, which were modified from those developed by Robert Seidel (personal communication, February 1989); and (c) to provide students a five-minute practical exercise in using relaxation and mental rehearsal to practice a gunnery engagement. The soldiers were also informed that they would receive mental rehearsal reminders immediately prior to each of the three I-COFT training sessions. At the conclusion of the briefing, soldiers in the experimental condition were instructed not to talk to anyone outside their platoon about mental practice procedures. The mental practice briefing lasted approximately 25 mins.

I-COFT pretest. All soldiers were initially tested on their gunnery skills by taking a standardized I-COFT examination, exercise number E-1. Exercise E-1 is a 17-min gunnery performance test that is usually administered at the end of Week 9 to assess the soldiers' achievement during I-COFT training. It consists of 10 simulated engagements of single main gun or single coax targets using precision gunnery techniques. Engagements consist of a mix of stationary/moving targets as well as stationary/moving owntank conditions. The pretest was administered on an individual basis by the I-COFT I/Os, who were explicitly instructed not to prompt the students or to provide any feedback to them during this period.

Mental practice reminders. A printed reminder to mentally rehearse was provided to each soldier in the experimental group before each of the three I-COFT training sessions. The reminder instructed soldiers to mentally rehearse a gunnery engagement for five mins. After the five mins had elapsed, students were required to describe his mental practice experiences using questionnaire items printed on the back of the reminder. The purpose of the reminders to mentally rehearse were to provide an explicit cue to mentally practice, and the purpose of the questions on the back were to ensure adherence to the mental practice procedures as instructed in the initial briefing. A copy of this reminder is included at Appendix B. This session occurred in the hallways of the building where the I-COFT training bays are located. At the end of the session, the soldiers were reminded to continue to use mental practice techniques during I-COFT training, especially during the down periods when they would not be physically practicing gunnery. The first reminder was presented immediately following the pretest but before actual training in the first block of I-COFT training. The second and third reminders occurred immediately prior to the second and third blocks of I-COFT training. After receiving the mental practice reminders, I-COFT training was conducted by I/Os according to their standard operating procedures.

I-COFT posttest and questionnaire. All soldiers were tested again on I-COFT Exercise E-1 at the end of the third block of training. The content and conditions of the posttest were identical to those of the pretest. Immediately following the I-COFT test, all soldiers, including those in the control group, were administered a posttest questionnaire that assessed the quantity and quality of mental practice experiences and their subjective impression of its effectiveness. The posttest questionnaire is included at Appendix C.

Dependent Measures

The results from the experiment were described in terms of two sets of dependent measures described below.

Self-reports of mental practice experiences. The first set of data were self-reports of mental practice experiences. The purposes of these data were (a) to determine whether or not soldiers mentally practiced as instructed, and (b) to describe the quality of their mental rehearsal experiences. These data were obtained from the responses to the posttest questionnaire (Appendix C) administered after the I-COFT posttest.

Gunnery performance. The second set of measures were based on performance on I-COFT Exercise E-1 at both the pretest and posttest. These data addressed the question of whether or not mental practice had an effect on gunnery performance. Hardcopy printouts of I-COFT performance were used to calculate three indexes of gunnery performance: firing rate, hit probability, and hit rate. Firing rate is intended as a measure of speed of performance and is defined as the number of rounds fired per minute of target exposure time. Hit probability is regarded as a measure of the accuracy of performance and is defined as the proportion of targets hit divided by the total number of targets presented. Finally, hit rate is a composite measure of speed and accuracy and is defined as the number of target hits achieved per minute of target exposure. Details on calculating these measures may be found in Hoffman and Witmer (1989).

Statistical Analysis

For both self-report and I-COFT performance data, the independent variables included one nominal treatment variable (experimental vs. control) and three quantitative measures of individual differences (GT composite from ASVAB, Betts' QMI scale, and Rotter's I/E scale). Cohen (1968) recommended multiple regression techniques for designs that include both nominal and quantitative independent variables. However, he cautioned that such analysis techniques can potentially generate many independent relationships, each of which could be tested for statistical significance. The number of factors tested could quickly approach the number of subjects (*n*) leading to significant research-philosophical and statistical problems. To avoid such problems, Cohen suggested that complex analyses be organized into "...a hierarchy of sets of independent variables, ordered, by sets, according to a priori judgments" (p. 442). The highest level of the hierarchy includes independent variables that the experimenter thinks are most relevant to the dependent variable. The next level of analyses in this hierarchy consists of interactions that are viewed less as hypotheses and more as exploratory issues. Finally, the lowest level of Cohen's hierarchy comprise unqualifiedly exploratory hypotheses. This hierarchical approach was used to analyze the present results.

Preliminary analyses of the self-report and performance data decomposed the differences among the three platoons into two orthogonal, single *df* comparisons: that contrasting the means from the two platoons in the experimental condition, and that contrasting the mean of the two platoons in the experimental condition vs. the mean of the platoon serving as the no-treatment control. The results indicated the differences among the three platoons could largely be accounted for by the experimental-control contrast rather than the within-experimental condition contrast. To simplify the following analyses, the data from the two platoons in the experimental conditions were collapsed.

Results

The results from the two sets of dependent measures are presented separately in the first two sections below. The analyses were separated to provide simple and direct tests of the research hypotheses. The third and final section examines the relationships between the two sets of dependent variables, and explores some post hoc analyses of the data. Within each of the first two sections, the analyses are arranged according to the hierarchy prescribed by Cohen (1969). The highest level of his hierarchy corresponds to tests of the main effects of mental practice instruction on the dependent measures. The next hierarchical level provides tests of the first order interactions of the experimental treatment (mental practice) and the single individual difference factors. The lowest level includes the higher order interactions among the treatment and the various individual difference factors. The descriptive statistics for the first two levels of this data analysis are presented in tables and figures in the body of the text, whereas the corresponding inferential test statistics and accompanying probabilities are presented in Appendix D. The discussion of the results from the analyses assumes the standard criterion for rejection of null hypotheses, i.e., $\alpha = .05$ (two-tailed). Analyses corresponding to the lowest (exploratory) level were performed and commented upon, but the results were not formally reported.

Self-Reports of Mental Practice Experiences

The primary purpose of the questions on the back of the mental practice reminders was to ensure adherence to the mental practice procedures advocated in the initial briefing. Some of the questions were purposely designed to be "leading" to get the soldier to actively think about his own mental practice procedures and, hopefully, to improve the quantity and quality of rehearsals in subsequent mental practice sessions. As a result the questions were not designed to generate reliable self-report data. Nevertheless, the answers to the questions were cursorily examined to determine the extent to which the soldiers in the experimental group mentally practiced during the reminder sessions. Analyses showed no systematic differences in these answers across the three reminder sessions; consequently, the following data were obtained by collapsing across sessions. Soldiers in the experimental group reported mentally rehearsing gunnery engagements an average of 6.1 times ($SD = 3.4$) during the five-minute reminder sessions. This response implies that soldiers were able to mentally rehearse a complete gunnery engagement once every 50 secs. They reported destroying the target on virtually all of those rehearsals ($M = 5.7$, $SD = 3.3$), and more than 90% of the soldiers reported practicing all task components. In contrast to the questions on the back of the reminders, the questions on the posttest questionnaire were designed to provide a more comprehensive and valid index of mental rehearsal experiences. The analyses of these data are described in more detail below.

Main effects of treatment. The first question posed to both experimental and control subjects on the posttest questionnaire required the soldiers to estimate the number of mental rehearsals that they spontaneously performed while waiting for the I-COFT, in garrison, or elsewhere. Table 1 summarizes the responses to this item. As can be seen, soldiers in the experimental conditions reported only five episodes of mentally rehearsing

Table 1

Estimated Number of Mental Rehearsals Performed in Various Locations

Location of Self-Reported Mental Rehearsals		Group: Experimental	Group: Control
While waiting for I-COFT instruction	*M*	5.18	4.41
	(*SD*)	(7.60)	(5.11)
	n	57	27
In garrison	*M*	3.86	3.07
	(*SD*)	(6.08)	(4.08)
	n	58	28
Elsewhere	*M*	0.24	0.72
	(*SD*)	(0.76)	(2.22)
	n	58	29

gunnery while waiting for I-COFT. By comparison, the mental practice reminder data suggested that soldiers mentally practiced gunnery engagements about five-six times per sitting. On the basis of the reminder data, one would have expected estimates to be at least 15 mental rehearsals (5 rehearsals x 3 sessions). Perhaps soldiers in the experimental group interpreted the question as asking them to provide an average value for each of the three I-COFT sessions rather than a total number over all three sessions. Compared to the control group, the experimental group reported more episodes of mental rehearsals while waiting for the I-COFT and in garrison. However, the differences between groups on each of these three questions were small and unreliable. (See Appendix Table D-1 for summary of significance tests.) The lack of significant differences between groups in the number of reported mental rehearsals at the I-COFT was especially surprising in view of the fact that soldiers in the control group were not given explicit instructions to mentally rehearse while waiting for I-COFT.

The second item of the posttest questionnaire required the soldiers to categorize their mental practice technique as either (a) imagining oneself's actually performing the task (imaginal, first person), (b) watching oneself performing the task outside of the body (imaginal, third person), or (c) silently repeating the task steps in one's mind (verbal). The results from this question are presented in Table 2. A chi-square test of independence indicated significant differences between groups in their responses to this question, $X^2\ (2) = 8.554$, $p < .05$. An orthogonal decomposition of these differences indicated that the variance in responses could be accounted for largely by the fact that a majority of experimental subjects (56.4%) reported using one or the other type of imaginal coding whereas a majority of the

Table 2

Frequency and Percentage of Soldier Responses to the Posttest Questionnaire Item Asking Soldiers to Describe Mental Practice Technique

Technique	Experimental f	Experimental %	Control f	Control %
Imaginal, 1st Person	17	30.9	3	11.1
Imaginal, 3rd Person	14	25.5	3	11.1
Verbal	24	43.6	21	77.8

control group (77.8%) reported using verbal coding, X^2 (1) = 8.525, $p < .01$. In contrast, the groups did not differ in their use of either type of imaginal coding, X^2 (1) = 0.029. Thus, it appears that the mental practice technique reported by the control subjects was different than that reported by experimental subjects: The experimental subjects were more likely to report mental practice based on mental imagery, whereas control subjects were more likely to verbally repeat the steps in their mind. In other words, compared to control subjects, the experimental subjects were more likely to report using the mental practice techniques that they were instructed to use.

The last five items of the posttest questionnaire were scaled items where the soldiers were asked to describe and evaluate their mental practice experiences. Figure 1 depicts the mean responses to each of these questions in relation to their corresponding scales. Appendix Table D-2 presents a summary of the analyses of between-group differences as well as exact means and standard deviations. In agreement with the previous analyses, the experimental group demonstrated that they were affected by the mental practice instructions by estimating that they mentally rehearsed more parts of the gunnery engagement than the control group and that they completed the task to the point of squeezing the trigger more often than the control group. These analyses indicate that group differences on these items were large and reliable. Smaller differences were obtained on the questions relating to how often they destroyed the target and the clarity of the mental images. Of these two differences, only the latter even approached significance, $p = .055$. The final question addressed the soldier's general evaluation of mental practice as a method for improving I-COFT performance. No differences were demonstrated between the ratings of control and experimental group on this item. This finding suggests that the instruction on mental practice failed to change the soldiers' subjective evaluation of this performance enhancement technique.

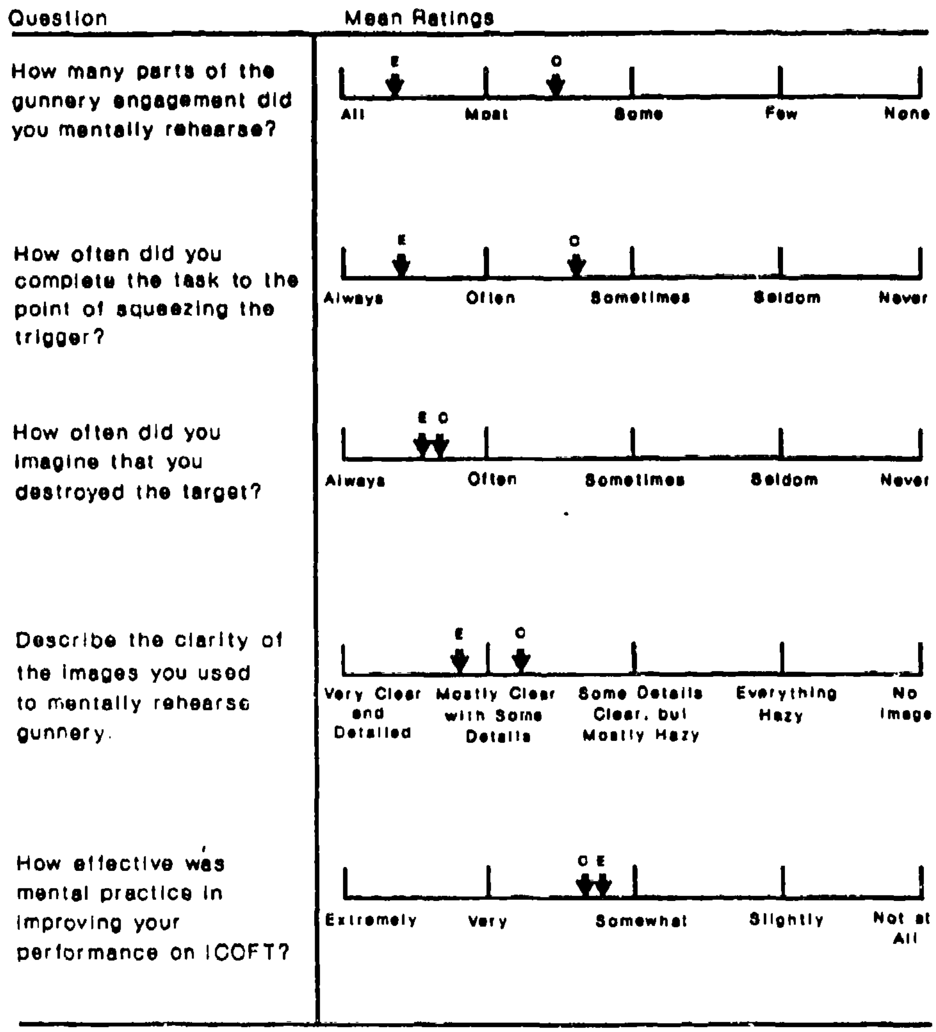

Figure 1. Mean responses of experimental (E) and control (C) groups to scaled items on posttest questionnaire.

<u>Interactions of treatment and individual difference factors</u>. The relationships between the scaled questionnaire items and individual difference measures are displayed as scatterplots shown in Figures 2-4 for GT, the Betts' QMI, and Rotter's I/E, respectively. Regression lines for the two groups are superimposed onto these plots, which also display the zero-order correlation coefficients between individual differences and questionnaire responses for experimental (E) and control (C) groups. The responses to the questionnaire items were scored from one to five corresponding to the order of alternatives

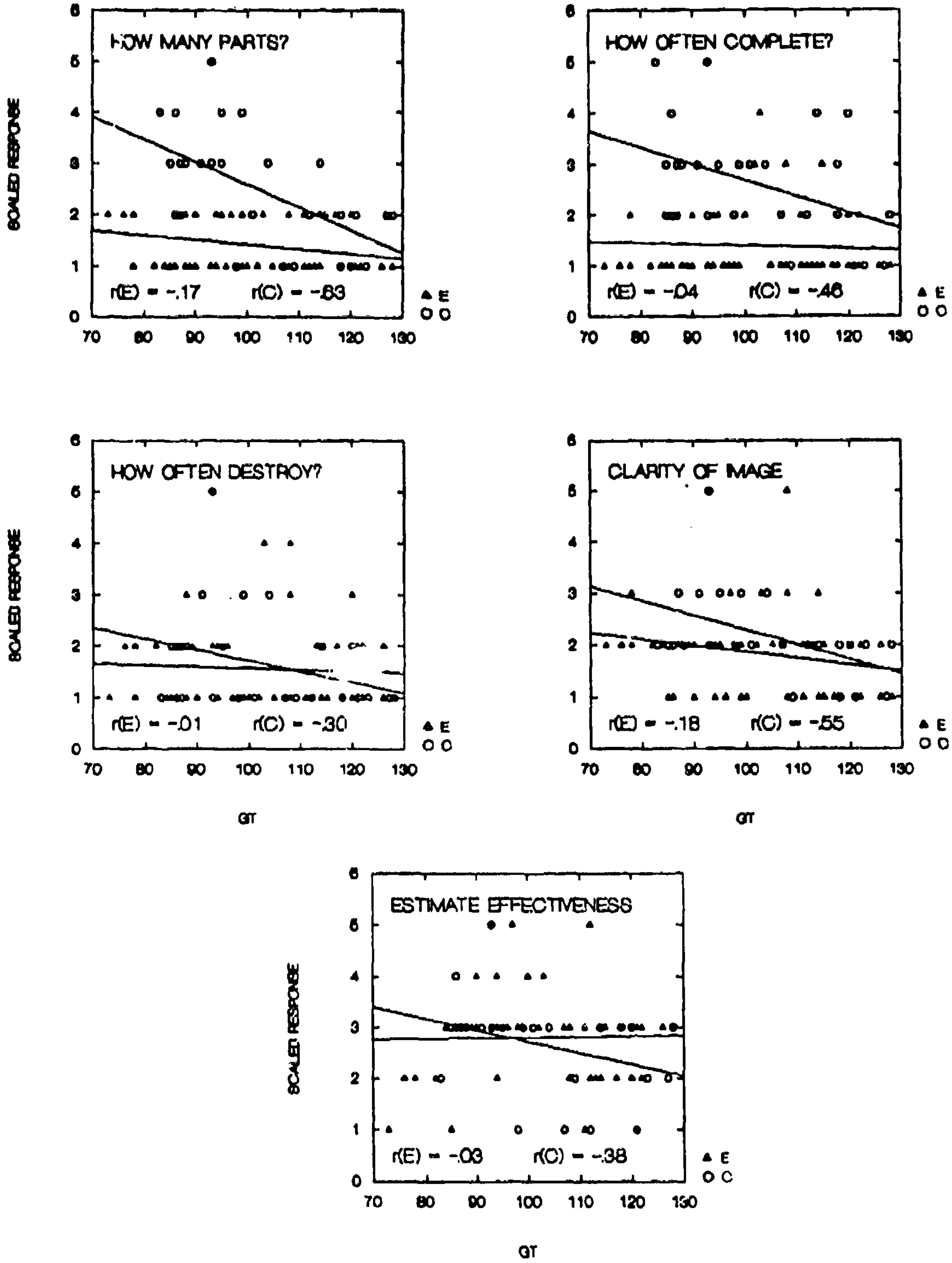

Figure 2. Regression of responses to five scaled questionnaire items on General Technical (GT) scores for experimental (E) and control (C) groups.

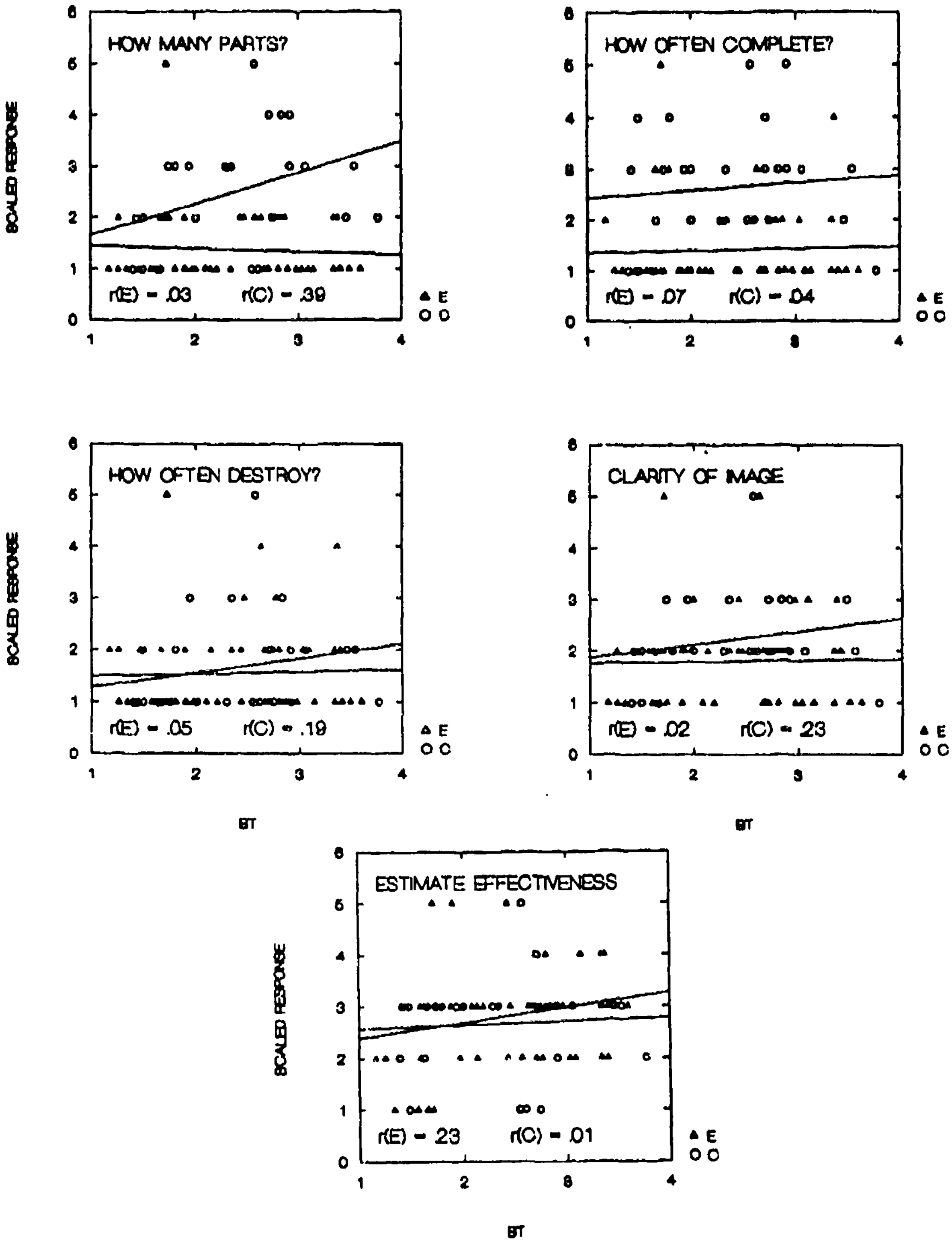

Figure 3. Regression of responses to five scaled questionnaire items on overall scores from Betts' Questionnaire on Mental Imagery (QMI) for experimental (E) and control (C) groups.

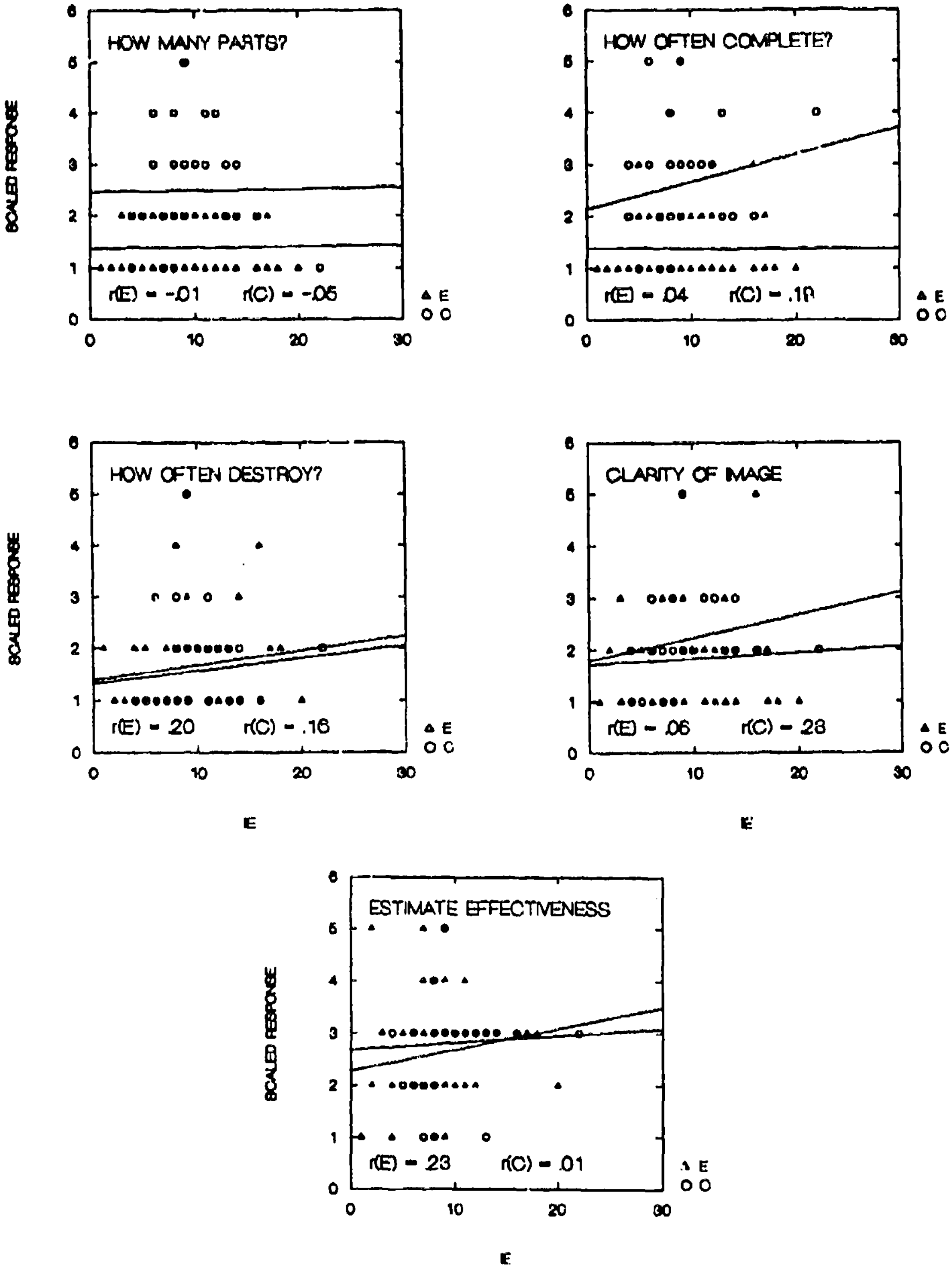

Figure 4. Regression of responses to five scaled questionnaire items on Rotter's Internal/External (IE) Locus of Control scores for experimental (E) and control (C) groups.

shown in Figure 1. That is, the lowest score (one) was assigned to the response most indicative of instructed mental practice procedures or (in the case of the last item) most indicative of a positive assessment of mental practice; the highest score (five), then, was least indicative of those reports.

Figure 2 indicates that, over both groups, GT was negatively related to questionnaire ratings. That is, soldiers with higher GT scores were more likely to report instructed mental practice procedures or to be more positive in their assessment of mental practice effectiveness. Furthermore, the regression lines appear steeper for students in the control group than for students in the experimental group, especially for the first two questions. To restate this relationship, the differences between groups were more pronounced for lower ability than for higher ability students. Analyses of these data (Appendix D-3) indicated that GT was significantly related to the responses to the first (How many parts?), second (How often complete?), and fourth (Clarity of image?) questions related to the quality of mental rehearsal experiences. Of more interest was the group X GT interaction, which was significant for the first two questions only. These significant effects indicate that the slopes of the regression lines (and hence the correlation coefficients) differ between groups for the responses to the first two questions.

As can be seen in Figure 3, the relationships between Betts' QMI and responses to the scaled items are generally positive. Note that the QMI is scaled such that low responses indicate high imaging ability. Thus, the positive correlations indicate that high imaging ability is associated with responses that are indicative of instructed mental practice procedures and with a positive assessment of mental practice effectiveness. Furthermore, as in the previous analysis, the regression lines appear steeper for students in the control group, especially for the first question. The analyses (Appendix D-4) indicate that the relationship between QMI and scaled responses approached significance ($p = .058$) for only the first item: the student's estimate of the number of task parts they practiced. The analysis of responses to this item also indicated a significant group X QMI interaction. No other relationships between QMI and scaled responses were significant. The regression lines shown in Figure 3 indicate that the interactive relationship of QMI and scaled responses to this question was similar to that between GT and responses, i.e., there were larger differences between experimental and control groups for students low in imaging ability than for students who scored higher in imaging ability.

Figure 4 presents the relationships between Rotter's I/E measure and responses to scaled questionnaire items. The relationships are generally positive indicating that internality (lower I/E scores) was associated with questionnaire responses indicative of instructed mental practice procedures and positive assessments of mental practice effectiveness. Further, the regression lines suggest that this relationship is stronger for soldiers in the control than for those in the experimental group. However, relationships in Figure 4 are apparently smaller than in the previous two analyses. None of the zero-order correlations was significant. Similarly, none of the effects in the group X I/E analyses reached statistical significance (See Appendix Table D-5).

The questionnaire data were also analyzed to determine whether any of the higher order interactions of GT and QMI were significant. Expanded regression models were used to test the effects of groups, GT, QMI, and the four interactions: groups X GT, groups X QMI, GT X QMI, and groups X GT X QMI. For these more exploratory analyses, none of the effects was significantly related to responses on any of the five scaled questionnaire items. The apparent reason for the lack of significant effects was that the independent variables in this analysis were intercorrelated, thereby reducing the size of each effect. Most notably, GT and QMI were negatively correlated ($r = -.33$, $p < .01$) with one another indicating that higher GT scores were associated with lower QMI scores (i.e., higher imaging ability).

Gunnery Performance

The gunnery performance data were provided by the soldiers' scores on I-COFT test exercise E-1, which was administered at both the pretest and the posttest. The analyses of these data are described in detail below.

Main effects of treatment. Table 3 summarizes the data on the three performance measures as obtained at the pretest and the posttest. As expected, both groups improved in their performance from pre- to posttest. Contrary to expectations, examination of between-groups differences showed large differences at the pretest with the control subjects performing worse than the experimental subjects on all three measures of performance. Looking across test administrations, the control group shows larger gains in performance, approaching the performance levels of the experimental group at the posttest. Analyses of variance (ANOVAs) of these data are summarized at Appendix Table D-6. These analyses indicated very similar results for all three performance measures, i.e., significant effects for (a) the differences between experimental and control conditions (group), (b) the differences between pretest and posttest performance (trials), and (c) the interactions of group X trial. Differences between individual means were examined by *t*-tests, the results of which are summarized at Appendix Table D-7. Again the pattern of results is identical for all three measures: (a) the increases in performance from pre- to posttest were significant for the experimental as well as for the control group, and (b) the differences between control and experimental groups were significant at the pretest but not at the posttest.

Because of the differences between intact groups at the pretest, analyses of covariance (ANCOVAs) were performed on these data to statistically adjust means on the basis of their pretest scores. The homogeneity of regression assumption was tested for each of the three dependent variables. In no case did the regression of posttest on pretest performance differ between groups. Separate ANCOVAs were performed to test the differences between the adjusted mean scores, which are displayed in Table 4. The differences between groups in adjusted posttest means are, for each dependent variable, quite small. Results from the ANCOVAs showed that the groups differences were not significant, all Fs < 1. (See Appendix Table D-8 for a summary of the ANCOVAs). In other words, despite the larger gains in

Table 3

Summary Statistics for Three Measures of Gunnery Performance

Performance Variable Group	*n*	As Measured at Pretest *M*	Pretest (*SD*)	Posttest *M*	Posttest (*SD*)
Firing Rate					
Experimental	59	.0664	(.0168)	.0722	(.0107)
Control	29	.0532	(.0233)	.0706	(.0156)
Hit Probability					
Experimental	59	.670	(.203)	.824	(.105)
Control	29	.433	(.273)	.777	(.150)
Hit Rate					
Experimental	59	.0538	(.0179)	.0657	(.0125)
Control	29	.0354	(.0246)	.0611	(.0173)

Table 4

Adjusted Posttest Means from the ANCOVAs

Performance Measure	Group Experimental	Control
Firing Rate	.0709	.0733
Hit Probability	.810	.806
Hit Rate	.0636	.0655

performance shown by the control group, the ANCOVAs failed to reveal reliable between group differences after controlling for pretest differences. It should be noted, however, that the ANCOVA would not be sensitive to treatment effects if the benefits of mental rehearsal occurred prior to the pretest, i.e., from knowledge derived from the introductory briefing and not the mental rehearsal sessions themselves.

Interactions of treatment and individual difference factors. The relationships between gunnery performance and individual difference measures are illustrated as scatterplots shown in Figures 5-7 for GT, the Betts' QMI, and Rotter's I/E, respectively. As in the previous series of figures, regression lines are superimposed onto the plots, which also display the zero-order correlation coefficients between GT and responses within the experimental (E) and control (C) groups. The three rows of plots represent the three gunnery performance measures, while the columns differentiate performance on the pretest and posttest. All three sets of scatterplots also provide evidence that scores in hit probability were near the performance ceiling of 1.0 on the posttest, which may have lessened group differences for this measure. Performance ceiling effects were less evident for the firing and hit rate measures.

Figure 5 indicates that the correlation between GT and performance is generally positive. That is, higher ability is associated with better gunnery performance. As in the previous analysis of self-report data, the regression lines are steeper in the control than in the experimental group. That is, whereas lower ability students in the experimental group are superior to lower ability students in the control group, the group differences disappear for higher ability students. Analyses of these data (summarized in Appendix Table D-9) indicated that GT was significantly related to all three measures. The group X GT interaction was significant only for the composite (hit rate) measure, although it approached significance for the firing rate measure ($p < .08$). Finally, note that the group X GT X trials interaction was not significant for any of the three measures. This finding indicates that the group X GT interaction did not differ across repeated test administrations.

Figure 6 suggests that scores on Betts' QMI are negatively correlated with gunnery performance. In other words, scoring lower on the QMI (indicating high imaging ability) is associated with higher gunnery performance. Again, regression lines are steeper for control than for experimental groups suggesting a treatment X individual difference interaction. In other words, among low imaging ability students, there appears to be an advantage to experimental over control conditions; however, the differences between groups disappear as imaging ability increases. Analyses of these data (Appendix Table D-10) indicate that the QMI was significantly related to hit probability and hit rate, but that the relationship between QMI and firing rate only approached significance, $p < .07$. The group X QMI interaction was significant for firing rate and hit rate but not for the hit probability measure. Finally, the group X QMI interaction did not differ across trials as indicated by the nonsignificant triple (group X QMI X trials) interaction.

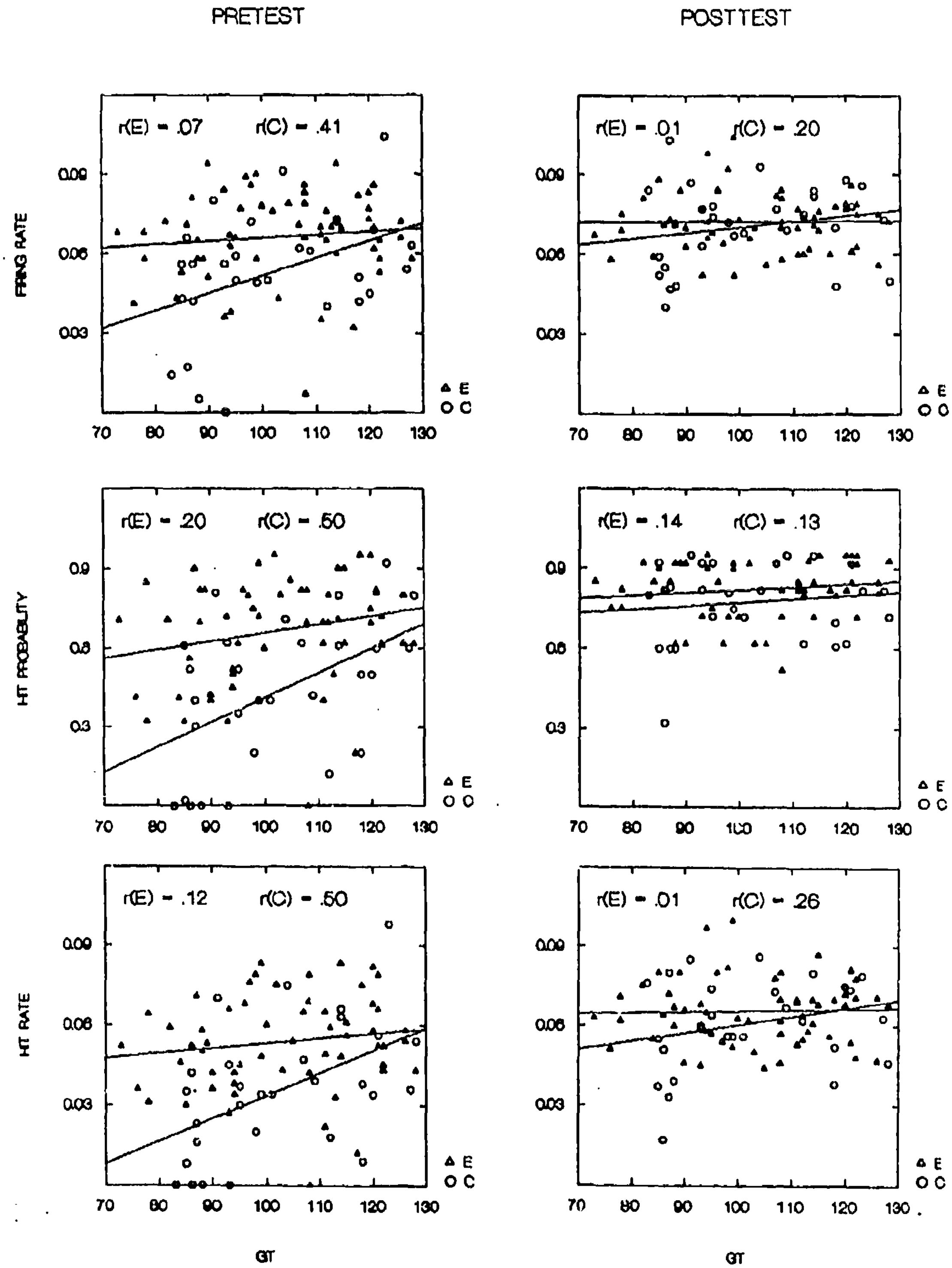

Figure 5. Regression of three dependent variables measured at pre- and posttest on General Technical (GT) scores for experimental (E) and control (C) groups.

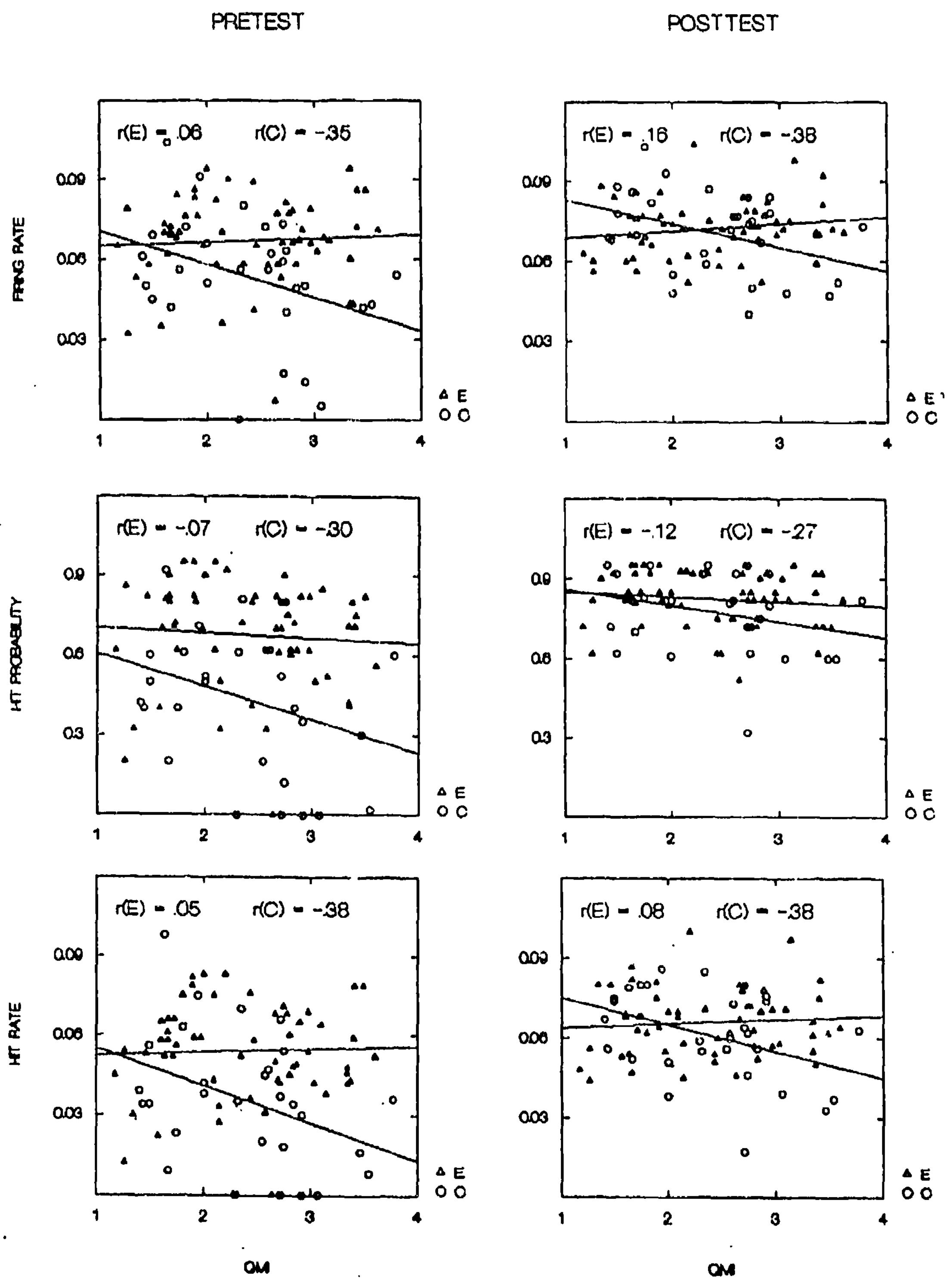

Figure 6. Regression of three dependent variables measured at pre- and posttest on overall scores from Betts' Questionnaire on Mental Imagery (QMI) for experimental (E) and control (C) groups.

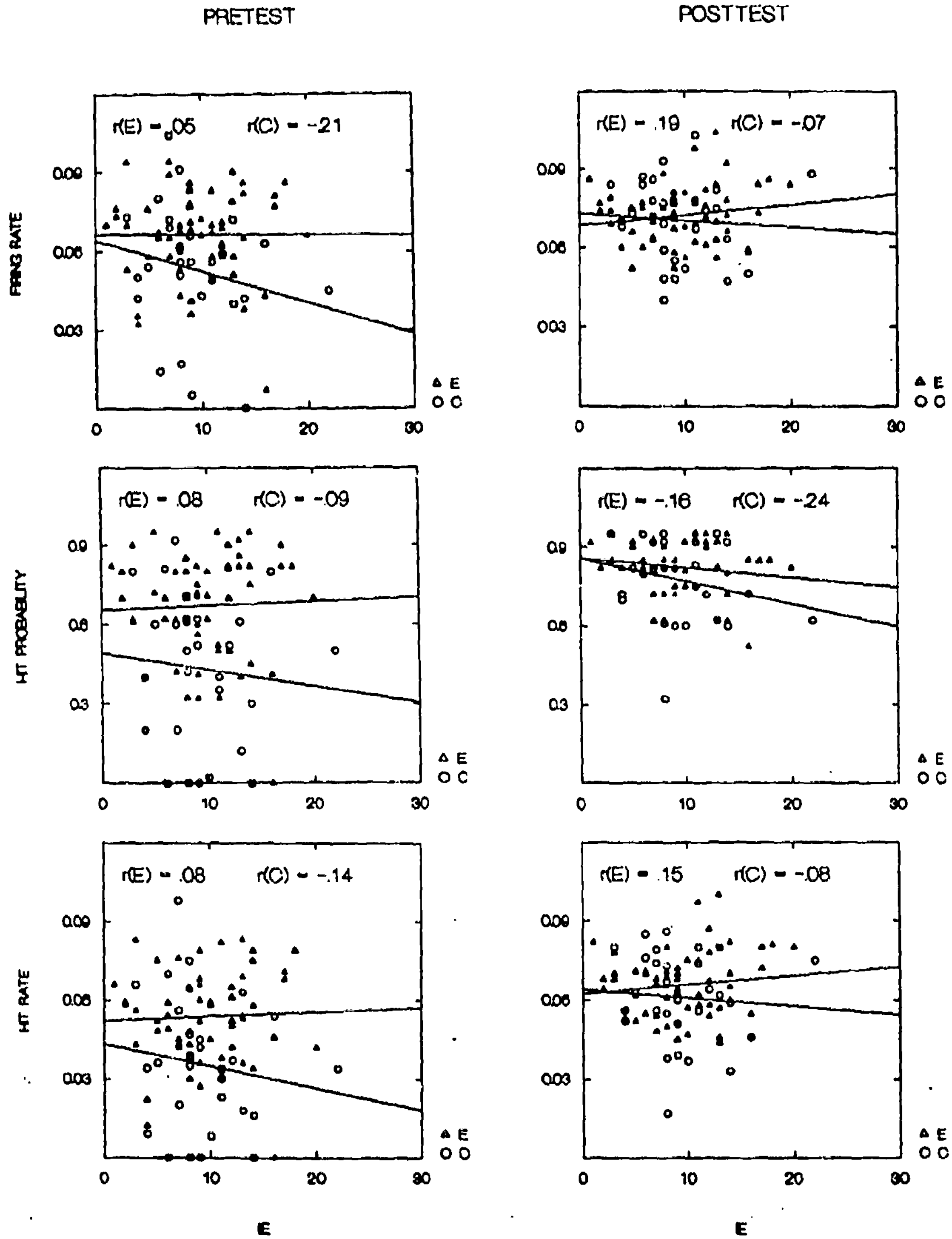

Figure 7. Regression of three dependent variables measured at pre- and posttest on Rotter's Internal/External (IE) Locus of Control scores for experimental (E) and control (C) groups.

As shown in Figure 7, the regression lines of gunnery performance on Rotter's I/E scale appear less steep than the previous two sets of relationships. Although none of the bivariate correlations were significant, the preponderance of negative correlations suggest that better performance is associated with lower (more internal) I/E scores. Analyses of these data (Appendix Table D-11) showed that the I/E variable was not significantly related to either of the three measures; nor did this variable interact with any of the other variables in the design.

As in the self-report data, exploratory analyses were also performed on the performance data to determine whether any of the effects of group, GT, QMI, and their interactions were significant. Again, none of the effects was significant for either of the three dependent measures.

Relationships between Self-Reports and Gunnery Performance

Bivariate correlations among the dependent measures are presented in Table 5. In general, the data indicate correlations among the scaled items on the posttest questionnaire and among U-COFT performance measures, but not between the two types of measures. That is, the different measures of self-report tended to be intercorrelated as did the different performance measures; however, the two sets of measures were not highly related to each other. These data suggest that the self-report and performance data are measuring independent constructs. An interesting exception to this generalization are the observed correlations in the experimental group between posttest hit probability and scaled questionnaire items, especially those two relating to the number of target destructions ($r = -.42$) and perceived clarity of the image ($r = -.44$). The negative correlations in the first four items indicate that good performers were more likely to report mental rehearsal experiences that were congruent with instructed mental rehearsal procedures. The last scaled item asked soldiers to estimate the effectiveness of mental practice procedures. In contrast to the previous four items, this final item was positively correlated with pretest performance. That is, favorable evaluations of mental practice were associated with poor performance on the pretest.

The correlations between posttest performance and the first four scaled response items on the questionnaire could be interpreted as evidence that the effects of mental practice were mediated by the quality of those practice experiences. According to this interpretation, the extent to which mental practice is effective is dependent upon how well soldiers follow mental practice instructions. Furthermore, this interpretation could be used to explain the lack of effect for mental practice. That is, the lack of differences between groups may have been due to the fact that the mental practice instructions were not understood by everyone in the experimental condition. Therefore, those who provided self-reports that were congruent with instruction should show the most improvement. Since the correlational data indicated the correlations were most evident for hit probability, let us assume that mental practice primarily affects the accuracy of performance. Accordingly, two post hoc analyses of the hit probability were performed using

Table 5

Intercorrelations of Dependent Measures

Source / Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Experimental Condition[a]														
Number of Mental Rehearsals														
1. While waiting	1.00													
2. In garrison	0.55**	1.00												
3. Elsewhere	-0.08	0.00	1.00											
Responses to Scaled Questionnaire Items														
4. Number of task parts	-0.24	-0.14	0.06	1.00										
5. How often completed?	-0.13	-0.17	0.04	0.60**	1.00									
6. How often destroyed?	-0.00	-0.07	-0.02	0.53**	0.61**	1.00								
7. Describe clarity	-0.26	-0.02	-0.04	0.53**	0.51**	0.58**	1.00							
8. How effective?	-0.03	0.10	-0.12	0.25	0.33	0.12	0.28*	1.00						
I-COFT Performance at Pretest														
9. Firing rate	0.02	-0.03	-0.08	-0.10	-0.06	-0.21	-0.15	0.29*	1.00					
10. Hit probability	0.01	-0.02	-0.12	-0.10	-0.04	-0.09	-0.04	0.21	0.73**	1.00				
11. Hit rate	0.04	-0.00	-0.15	-0.10	-0.08	-0.13	-0.03	0.27*	0.86**	0.88**	1.00			
I-COFT Performance at Posttest														
12. Firing rate	0.16	0.23	0.08	-0.15	-0.05	-0.04	-0.23	0.05	0.46**	0.36**	0.45**	1.00		
13. Hit probability	0.16	0.18	0.09	-0.31*	-0.26*	-0.42**	-0.44**	-0.19	0.19	0.20	0.16	0.34**	1.00	
14. Hit rate	0.16	0.24	0.12	-0.15	-0.10	-0.18	-0.29*	0.01	0.42**	0.36**	0.42**	0.92**	0.57**	1.00
Control Condition[b]														
Number of Mental Rehearsals														
1. While waiting	1.00													
2. In garrison	0.26	1.00												
3. Elsewhere	0.24	0.21	1.00											
Responses to Scaled Questionnaire Items														
4. Number of task parts	-0.23	-0.26	-0.16	1.00										
5. How often completed?	-0.02	-0.44*	-0.29	0.67**	1.00									
6. How often destroyed?	-0.27	-0.25	-0.21	0.65**	0.58**	1.00								
7. Describe clarity	-0.22	-0.40*	-0.28	0.65**	0.57**	0.80**	1.00							
8. How effective?	-0.17	-0.61**	-0.38	0.61**	0.60**	0.65**	0.59**	1.00						
I-COFT Performance at Pretest														
9. Firing rate	0.24	0.21	0.07	-0.32	-0.32	0.09	0.10	-0.21	1.00					
10. Hit probability	0.24	0.20	0.13	-0.19	-0.24	0.18	0.18	-0.01	0.85**	1.00				
11. Hit rate	0.30	0.23	0.03	-0.20	-0.23	0.18	0.14	-0.09	0.90**	0.94**	1.00			
I-COFT Performance at Posttest														
12. Firing rate	0.02	0.06	-0.10	-0.04	0.11	0.11	0.19	-0.23	0.47**	0.40*	0.46*	1.00		
13. Hit probability	0.17	0.18	0.31	-0.10	-0.28	-0.03	0.02	-0.30	0.47*	0.51**	0.51**	0.57**	1.00	
14. Hit rate	0.12	0.13	0.02	-0.09	-0.01	0.05	0.10	-0.31	0.53**	0.53**	0.60**	0.94**	0.76**	1.00

[a]Pairwise correlations in the experimental condition were based on *ns* varying from 56 to 59.
[b]Pairwise correlations in the control condition were based on *ns* varying from 25 to 29.
* $p < .05$
** $p < .01$

experimental condition as a nominal independent variable and first number of target destructions and then perceived clarity as quantitative independent variables. If the quality of rehearsal were mediating the effect, one would predict an interaction of the self-report variables and trials. The results of the analyses (presented in Appendix Table D-12) failed to show a main effect for either self-report variable, an interaction of these variables and trials, or a three-way interaction with groups. Thus, these analyses failed to support the mediation interpretation of the correlations between self-reports and actual performance.

Another possible explanation for the failure to find differences between groups was that mental practice instruction was irrelevant because mental rehearsal is a learning strategy that most soldiers possessed. Evidence for this view was the uncontrolled mental rehearsal activity reported in the control group. One posthoc analysis strategy would be to examine group differences while statistically controlling for the amount of mental rehearsal activity. However, examination of the correlations between the amount of mental rehearsal activity and performance reveal the relationships were generally positive but nonsignificant. Two of the correlations in the experimental group involving number of estimated rehearsals in garrison and posttest performance firing rate ($r = .23$) and posttest hit rate ($r = .24$) approached but did not attain significance, $.05 <$ both ps $< .10$. Similarly, there was a positive, but nonsignificant correlation in the control group between the number of mental rehearsals performed in places other than while waiting for I-COFT of in garrison, $r = .31$, $p \approx .10$. Because the relationships were not significant, the posthoc analysis strategy was deemed inappropriate.

Discussion

Effects of Mental Practice Instruction on Self-Reports

The results from the analyses of self-reports showed that soldiers in the control group as well as the experimental group reported having mental practice experiences. One possible explanation of this finding is that students in the control group learned about mental practice techniques from experimental students, despite explicit instructions to refrain from discussing the experiment outside of the platoons. Arguing against this interpretation is the finding that students in the experimental group were more likely to describe mental practice experiences that were more in accordance with mental practice instructions. These instructions stressed that soldiers mentally rehearse the entire engagement from the first-person point of view using vivid imagery. In other words, the findings suggest that, without instructions, students will *think* about the task; with instructions, they will *picture* the task as prescribed by mental practice techniques.

The effects of mental practice instruction must be interpreted in light of the interaction between group and general ability as defined by the GT composite of the ASVAB. This interaction indicated that group differences in self-reports were larger for low ability than for high ability soldiers. In other words, self-reports from high ability soldiers in the control group were similar to the reports from experimental soldiers in terms of the tendency to report mental practice procedures that were congruent with the those advocated in the instructions. This finding is important in that it provides evidence that intelligent learners are more likely to spontaneously mentally rehearse in an appropriate manner, i.e., one that is consistent with the mental practice literature. Note that Richardson's (1967) review of the mental practice literature identified only five studies that addressed the relationship of intelligence and mental practice with only one of the five (Perry, 1935) indicating a significant positive relationship between intelligence and performance after mental practice. Note, however, that these previous findings were based on actual performance, whereas the present findings are based on self-reports of mental practice. The findings may not be contradictory if one assumes that high ability performers do mentally practice better, but that the individual differences in covert rehearsal are not sufficiently large to generate detectable differences in overt performance.

The findings from the self-reports begs a more basic research issue. The issue is the extent to which researchers can obtain objective data on covert processes such as mental practice. Ericsson and Simon (1984) have closely examined several techniques for interpreting verbal reports of mental processes. In their terminology, the posttest questionnaire was essentially a retrospective report, i.e., one that is initiated after a task is completed. Because retrospective reports focus on mental processes that are no longer active, the subject must sometimes report on aspects of mental processes that he can no longer remember. In this situation, subjects sometimes will infer or generate answers on the basis of information from sources other than their own mental processes. To avoid the problem of forgetting, Ericsson and Simon recommended using concurrent reporting where the subject talks aloud about his mental processes as he performs the task. Two problems prevented using this technique in the present experiment. First, the mental processes that are reported to be most effective in mental practice are based on mental imagery. The extent to which this mental imagery can be expressed in verbal, symbolic terms is problematic. Second, talk aloud procedures during task performance usually require an experimenter to closely monitor and interact with subjects in one-on-one fashion. Such extensive and intensive data gathering for each individual soldier was not possible within the time constraints of the present experiment. Despite these problems, the applicability of concurrent self-reports to mental practice should be explored further.

Since the retrospective report was used in the present research, it is appropriate to speculate as to what sorts of inferences might have distorted the self-reports of mental practice. One possibility is that soldiers made inferences based on the expectation that mental practice should have been effective. In fact, one could interpret the correlations between self-reports and actual performance in terms of such expectations. Recall that the posttest questionnaire was administered after the I-COFT performance test and that soldiers in the experimental group had been initially instructed that performance gains could be achieved through the use of this technique. Thus, the reactions to the scaled items on the questionnaire may have reflected soldiers' interpretations of their posttest performance. That is, soldiers might interpret good performance as due to the use of effective mental imaging on their part. Furthermore, it would explain the fact that the correlations were observed in the experimental group and not in the control group, the latter presumably not having an expectation about the relationship between mental practice and performance. Two other sets of correlations that were observed in the experimental but not in the control group also support the expectation interpretation. First, a correlation was observed in the experimental group between the quality of mental practice and its perceived effectiveness. That is, soldiers whose self-reports of mental practice were more in line with instructed procedures were more likely to rate mental practice as effective. Second, a correlation was observed in the experimental group between the evaluation of mental practice and pretest performance such that positive evaluations were associated with low pretest performance. Poor pretest performance could have been perceived as due to the fact that soldiers in the experimental group had not started to use the mental practice techniques. Although the expectation interpretation is admittedly speculative, it does suggest that retrospective self-reports should be critically examined for the influence of possible subject-generated inferences.

Effects of Mental Practice Instruction on Gunnery Performance

Analyses of group differences failed to provide evidence that mental practice affected either the speed or the accuracy of gunnery performance. However, conclusions from these results are difficult to draw given the initial differences between experimental and control groups on the pretest. Analyses of treatment interactions suggested that group differences were larger for soldiers low in GT or in imagining ability. This interaction cannot be attributed to mental practice, however, because the effects existed at the pretest as well as the posttest. One possible explanation for these results is that the initial mental rehearsal briefing (apart from the mental rehearsal sessions) had a positive affect on the performance of the experimental group at the pretest. Recall that the initial briefing occurred prior to the pretest, but the pretest occurred immediately prior to the beginning of the first mental practice session. It is conceivable that low ability soldiers may have derived more benefit from these instructions than higher ability soldiers. However, the magnitude of the differences at pretest make this explanation unlikely. Finally, anecdotal evidence suggests that differences between experimental and control groups existed prior to the experiment: Drill sergeants and I-COFT instructors who had experience with all three platoons reported that they had observed differences in gunnery performance in the first week of I-COFT training. Unfortunately, this information was obtained only after platoons had been assigned to conditions.

The problem with explaining null results is that they may have been caused by virtually an unlimited number of factors, none of which are mutually exclusive. One possible explanation for these results is that soldiers did not understand or correctly implement mental practice procedures. Statistical analyses that evaluated performance with respect to self-reports of mental rehearsal activities failed to support this interpretation. Another explanation for the lack of differences is that the performance measures were insensitive to the treatment. This may have been a particular problem for the hit probability measure: Scores were at or near the performance ceiling of 1.0 at the posttest thereby masking group differences. However, ceiling effects were not observed in the other two measures that also failed to show between-group differences.

Perhaps the most straightforward explanation of the null results is that the mental practice techniques were not effective in this situation. One important aspect of the present situation was the gunnery task itself. In their review, Feltz and Landers (1983) showed positive effects of mental practice for a wide variety of tasks. However, mental practice was more effective for cognitive tasks (e.g., finger maze, card sorting, symbol digit test, etc.) than for purely motor tasks (rotary pursuit, free throw shooting) or strength tasks (situps, hand grip strength). They concluded that mental practice primarily affects the cognitive-symbolic rather than the motor elements of the task. Gunnery more closely resembles the cognitive tasks in their review than the motor or strength tasks, which suggests that mental practice should be effective for gunnery tasks. Thus, it is unlikely that gunnery tasks are inherently insensitive to mental practice effects. To directly address this issue, however, the cognitive content in gunnery should be systematically varied in future research by introducing decision making requirements such as those related to degraded mode gunnery or to tactical considerations. Analyses can then be performed to determine whether the effect of mental practice is dependent upon the cognitive content of gunnery tasks.

Another important aspect of the present situation was that entry-level soldiers were in the early stages of skill acquisition. Current theories of skill acquisition hold that learners initially attend to the cognitive elements of the task before the motor elements. Schmidt (1982) suggested that mental practice should therefore have its greatest effect on the early stages of learning. Other researchers (Corbin, 1967; Phipps & Morehouse, 1969) have provided evidence for the other point of view, i.e., that the effectiveness mental practice is dependent upon prior experience with the task. Feltz and Landers' (1983) meta-analytic review of the literature failed to show a clear-cut difference as a function of experience. They concluded that "...mental practice effects are found at the initial and later stages of learning" (p. 47). Thus, it is also unlikely that the null results are due to the fact that soldiers are in the early stages of learning. However, future research may address this issue by assessing the effects of mental practice at different stages in learning.

In addition to these theoretical reasons for the null results, there were some methodological or statistical factors that could have contributed to the null results. One obvious problem was the nonequivalence of the intact groups: performance of the experimental group was initially superior to that of the control group. As a consequence of their higher initial performance, the experimental group showed smaller gains in their posttest performance compared to the control group thereby masking any improvement due to mental practice. When the initial differences were statistically controlled through ANCOVA techniques, between-group differences on the posttest were not significant. Evans and Anastasio (1968) noted that although ANCOVA was originally developed to correct for differences in intact groups, the between-group differences in the covariate should be "relatively small" so that the treatment-covariate correlation is low. The differences between groups in the present study, in contrast, were large and significant thereby increasing the likelihood that the data violated the assumption of independence of additive components. Thus, the ANCOVA correction may have produced spurious results. Clearly, the less troublesome design would have been to randomly assign soldiers to groups. In the present design, random assignment was out of the question given the constraints of entry-level armor training. Future research should investigate the effects outside of this restrictive context and address questions such as whether mental practice is effective at all for gunnery and what are the key variables that control its effectiveness. The cost of tighter control of experimental variables is a lessening in the external validity of the research. However, ecologically valid studies (i.e., mental practice in actual training contexts) can be designed with a greater confidence only *after* more basic questions about mental practice have been addressed.

Another obvious methodological problem that possibly contributed to the null results was the uncontrolled mental practice activity in the control group. That is, mental practice activity reported in the control group, especially that among higher ability soldiers, may have reduced the differences between the experimental and control group. Attempts to statistically control mental practice were thwarted by the lack of correlation between self-reports of the number of mental rehearsals and performance. As reported by Feltz, Landers, and Becker (1988), previous researchers have typically attempted to eliminate mental practice in control groups by expressly prohibiting the activity or by having subjects perform some irrelevant activity. Such experimental control procedures are appropriate if the purpose of the research is to determine the contribution of mental practice to skill acquisition. These procedures are not appropriate, however, if the purpose is to evaluate the effectiveness of mental practice as an adjunct practice technique. The reason is that this procedure would introduce a restriction on students that does not exist in training. This problem further highlights the need to obtain measures of mental rehearsal activity that are independent from measures of overt performance.

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APPENDIX A

Script for Initial Mental Rehearsal Briefing

Introduction

Present Slide 1 at this point

In the following briefing, you will learn about a method of practice called mental rehearsal; you will learn about the related technique of relaxation training; and you will use these methods to mentally rehearse a gunnery engagement.

Present Slide 2 at this point

Mental rehearsal is defined as the process of practicing a physical activity in your mind. In other words, you practice by imagining yourself actually performing an activity such as a sport or a job task. Professional and college athletes have successfully used mental rehearsal to improve their performance in diverse areas such as basketball, hockey, golf, bowling, football, and handball. Famous sports figures such as baseball player Rod Carew, tennis champions Chris Evert and Stan Smith, skier Jean Claude Killy, and 1983 LPGA champion Patty Sheehan have all used a program of mental rehearsal to improve their performance. In sum, mental rehearsal has been proven successful and has been endorsed by many famous sports figures in a variety of fields.

The Army's Training and Doctrine Command has directed the Army Research Institute to test this method of practice in armor training, and the Armor School is very interested in the results of this test. Your platoon has been chosen to test the effectiveness of mental rehearsal techniques for improving performance on the ICOFT. We ask for your cooperation in this project. Moreover, we hope that you enjoy learning about and using this technique, which has the potential to improve performance in many different domains of human activity.

Relaxation Training

Present Slide 3 at this point

Mental rehearsal procedures are more effective if you are in a relaxed state of mind. This can be accomplished by a technique called relaxation training. The objective of this portion of the instructions is to provide some training in systematic relaxation.

As you sit in your chair, tense your body for 10 seconds and then relax. Tense...[10 secs]...now relax..[2 secs]. Notice the difference between the relaxed and tense states. Maintain that relaxed state as I read the following questions. The questions are designed to help you achieve a relaxed but alert frame of mind. Take a moment to think about each one. There are no right or wrong answers to these questions. However you react is fine. Now close your eyes and focus on your breathing.

- Is it possible to picture a peaceful place where you would like to be? [5 second pause]
- Is it possible to picture yourself in that peaceful place? [5 second pause]
- Is it possible for you to hear the rippling of water in a stream? [5 second pause]
- Is it possible to imagine yourself walking down a quiet hallway? [5 second pause]
- Is it possible for you to imagine a blue sky with clouds floating by? [5 second pause]
- Is it possible for you to have a calm and secure feeling? [5 second pause]
- Is it possible to feel yourself floating as if you were in water? [5 second pause]
- Is it possible for you to feel warm and comfortable? [5 second pause]
- Is it possible for you to count silently and slowly to ten? [10 second pause]

Note your present state: You should be relaxed but alert. We want you to be able to systematically relax yourself when you mentally practice for ICOFT. Now open your eyes but try to retain your relaxed state as we now begin the instructions for rehearsing a gunnery engagement.

Instructions for Mental Rehearsal of a Gunnery Engagement

Present Slide 4 at this point

The objective of the third and final portion of the instructions is to give you some practice mentally rehearsing a gunnery engagement. To mentally rehearse a gunnery engagement, you should envision yourself going through all the actions that you would perform to successfully destroy a threat target on ICOFT. Now relax and close your eyes again...[Pause]...Start by mentally visualizing the target and feeling the control handles as you track the target. Imagine the TC has acquired the target, slewed the turret toward it, and announced his fire command. In your imagination, flip the gun select switch to MAIN, and the GPS magnification switch to 10-power. You now look through the GPS, identify the target, and announce "IDENTIFIED". You wait for the loader to announce "UP" and then for the TC to announce "FIRE." You now make the final lay onto the target, and when ready to fire, you announce "ON THE WAY." Imagine squeezing the trigger and observing the round hitting and destroying the target...[Pause]. Now open your eyes. Could you visualize all that? Whenever you use mental rehearsal to practice gunnery, be sure to imagine the entire engagement as you have just done.

Present Slide 5 at this point

In the upcoming ICOFT sessions, we are going to ask you to mentally rehearsal while waiting for your turn on the ICOFT. We will be providing a written reminder to mentally rehearse the gunnery engagement for five minutes. To see how you are doing, we will ask you to fill out a few questions describing how well your five-minute mental rehearsal session went. We will repeat these exercises once during each of your final three sessions at Hill Hall.

To conclude this exercise, we want you to practice mentally rehearsing a gunnery engagement using the written instructions that are being handed out to you. This sheet is the same one that you will receive daily to remind you to mentally rehearse. If you have any questions, the project staff will answer them when you finish the mental rehearsal session. Read the instructions on the front page, try to relax using the techniques described earlier, and begin mentally rehearsing for five minutes. We will tell you when five minutes is over.

OBJECTIVES

- learn about mental rehearsal

- learn about relaxation training

- practice using both methods to mentally rehearse gunnery engagement

(Slide 1)

MENTAL REHEARSAL

- defined as practicing a physical activity in your mind
- used by sports professionals to improve performance
- has potential for improving armor gunnery training

(Slide 2)

RELAXATION TRAINING

- mental rehearsal more effective if you are relaxed
- focus on relaxation questions
- maintain relaxed but alert state

(Slide 3)

PRACTICE SESSION

- imagine destroying threat target on ICOFT
- picture in your mind each part of the engagement
- practice rehearsing engagement for 5 mins

(Slide 4)

DAILY SESSIONS

- will daily reminders to mentally rehearse
- fill out questions on back of reminders
- practice using instructions on sample reminder

(Slide 5)

APPENDIX B

Mental Rehearsal Reminder

(Front Page)

As we stated in the initial briefing, we want you to use mental rehearsal techniques during the time that you are waiting to get on the I-COFT. First, relax using the methods explained to you in the briefing. Tense your body, then relax. Close your eyes and count silently and slowly from 1 to 10. When you have achieved a relaxed but alert state, mentally picture yourself going though all the actions that you would perform to successfully destroy a threat target on the I-COFT. Remember to mentally rehearse the entire engagement. Continue mentally rehearsing the engagement for about five minutes. After you have finished rehearsing the engagements, please turn this sheet over and answer the questions on the back.

Mental Rehearsal Reminder

(Back Page)

Name:______________________ SSN:___________________

Unit:______________________ Date:___________________

1. How many times did you mentally rehearse the engagement?

   ____

2. Out of the total number of rehearsals, how many times did you imagine completing the engagement and destroying the target? ____

3. Did you mentally rehearse every part of the engagement?

   Circle: YES NO

   If you answered NO, indicate what part(s) of the engagement you left out.

APPENDIX C

Posttest Questionnaire

Name:___________________________ SSN:___________________________

Unit:___________________________ Date:___________________________

(Introduction for Students in the Experimental Group)

Over the last week, you have practiced using mental rehearsal techniques. The following questions are designed to assess the extent to which you used these techniques to prepare for gunnery on the ICOFT. To the best of your ability, please answer all of the following questions.

(Introduction for Students in the Control Group)

Athletes often mentally prepare for sports by imagining themselves actually performing the activities related to the sport. This technique is called <u>mental rehearsal</u>. The following questions are designed to assess the extent to which you used mental rehearsal techniques to prepare for gunnery on the ICOFT. To the best of your ability, please answer all of the following questions.

1. Estimate the total number of times you used mental rehearsal techniques to prepare for gunnery on U-COFT?

   ___ In garrison

   ___ While waiting on U-COFT partner

   ___ Any other place. If so, where:________________________

2. Indicate which of the following statements describe the technique that you used to mentally rehearse gunnery:

   ___ It was if I was inside my own body and actually performing the task.

   ___ It was if I was watching myself perform the task outside of my own body.

   ___ I silently repeated the task steps in my mind.

3. How many parts of the gunnery task did you mentally rehearse?

All of the Parts	Most of the Parts	Some of the Parts	A Few of the Parts	None of the Parts

4. When you mentally rehearsed gunnery, how often did you complete the task to the point of mentally squeezing the trigger?

Always	Often	Sometimes	Seldom	Never

5. When you mentally rehearsed gunnery, how often did you imagine that you destroyed the target?

Always	Often	Sometimes	Seldom	Never

6. Describe the clarity of the images that you used to mentally rehearse gunnery.

Very Clear and Detailed	Mostly Clear with Some Details	Some Details Clear, but Mostly Hazy	Everything Hazy	No Image

7. How effective was mental practice in improving your performance on U-COFT?

Extremely Effective	Very Effective	Somewhat Effective	Slightly Effective	Not Effective at All

APPENDIX D

SUMMARIES OF SIGNIFICANCE TESTS

Table D-1

Summary of *T*-tests Between Mean Numbers of Self-Reported Mental Rehearsals

Location of Self-Reported Mental Rehearsals	*df*	*t*	*p*
Waiting for ICOFT	82	0.476	.635
In garrison	84	0.622	.535
Elsewhere	85	1.499	.138

Table D-2

Group Means and Standard Deviations of Responses to Scaled Items on Posttest Questionnaire and Summary of *T*-tests Between Groups

Question		Group: Experimental	Group: Control	*t*	*p*
How many parts of the gunnery engagement did you mentally rehearse?	*M*	1.39	2.50	5.805	<.001
	(*SD*)	(0.67)	(1.11)		
	n	59	28		
How often did you complete the task to the point of squeezing the trigger?	*M*	1.39	2.64	5.997	<.001
	(*SD*)	(0.81)	(1.10)		
	n	59	27		
How often did you imagine that you destroyed the target?	*M*	1.56	1.67	0.511	.610
	(*SD*)	(0.88)	(0.96)		
	n	59	27		
Describe the clarity of the images you used to mentally rehearse gunnery.	*M*	1.83	2.22	1.947	.055
	(*SD*)	(0.87)	(0.85)		
	n	59	27		
How effective was mental practice in improving your performance on ICOFT?	*M*	2.81	2.67	0.697	.488
	(*SD*)	(0.87)	(0.92)		
	n	58	27		

Table D-3

Summary of Group by GT Analyses of Scaled Items from Posttest Questionnaire

Question Source	*SS*	*df*	*MS*	*F*	*p*
How many parts of the gunnery engagement did you mentally rehearse?					
Group	8.00	1	8.00	14.19	<.001
GT	11.12	1	11.12	19.74	<.001
Group X GT	4.83	1	4.83	8.57	.004
Error	46.78	83	0.56		
How often did you complete the task to the point of squeezing the trigger?					
Group	6.49	1	6.49	8.34	.005
GT	4.68	1	4.68	6.01	.016
Group X GT	3.31	1	3.31	4.25	.042
Error	64.56	83	0.78		
How often did you imagine that you destroyed the target?					
Group	1.34	1	1.34	1.67	.200
GT	2.20	1	2.20	2.74	.102
Group X GT	1.24	1	1.24	1.54	.219
Error	66.00	82	0.80		
Describe the clarity of the images you used to mentally rehearse gunnery.					
Group	1.42	1	1.42	2.05	.156
GT	6.08	1	6.08	8.76	.004
Group X GT	0.96	1	0.96	1.39	.242
Error	56.89	82	0.69		
How effective was mental practice in improving your performance on the ICOFT?					
Group	1.87	1	1.87	2.44	.122
GT	1.70	1	1.70	2.22	.140
Group X GT	2.17	1	2.17	2.83	.097
Error	62.11	81	0.77		

Table D-4

Summary of Group by Betts' QMI Analyses of Scaled Items from Posttest Questionnaire

Question Source	*SS*	*df*	*MS*	*F*	*p*
How many parts of the gunnery engagement did you mentally rehearse?					
Group	0.29	1	0.29	0.43	.514
QMI	2.49	1	2.49	3.71	.058
Group X QMI	3.64	1	3.64	5.44	.022
Error	53.57	80	0.67		
How often did you complete the task to the point of squeezing the trigger?					
Group	1.24	1	1.24	1.43	.235
QMI	0.30	1	0.30	0.34	.560
Group X QMI	0.10	1	0.10	0.12	.731
Error	69.66	80	0.87		
How often did you imagine that you destroyed the target?					
Group	0.27	1	0.27	0.33	.565
QMI	0.80	1	0.80	0.98	.326
Group X QMI	0.46	1	0.46	0.56	.456
Error	64.89	79	0.82		
Describe the clarity of the images you used to mentally rehearse gunnery.					
Group	0.02	1	0.02	0.03	.867
QMI	0.62	1	0.62	0.80	.373
Group X QMI	0.43	1	0.43	0.56	.457
Error	60.73	79	0.77		
How effective was mental practice in improving your performance on the ICOFT?					
Group	0.21	1	0.21	0.26	.610
QMI	1.05	1	1.05	1.31	.256
Group X QMI	0.40	1	0.40	0.50	.483
Error	62.68	78	0.80		

Table D-5

Summary of Group by Rotter's I/E Analyses of Scaled Items from Posttest Questionnaire

Question Source	*SS*	*df*	*MS*	*F*	*p*
How many parts of the gunnery engagement did you mentally rehearse?					
Group	3.43	1	3.43	4.83	.031
I/E	0.01	1	0.01	0.01	.922
Group X I/E	0.00	1	0.00	0.00	.999
Error	59.03	83	0.71		
How often did you complete the task to the point of squeezing the trigger?					
Group	1.56	1	1.56	1.87	.175
I/E	0.80	1	0.80	0.96	.329
Group X I/E	0.83	1	0.83	1.00	.321
Error	69.32	83	0.84		
How often did you imagine that you destroyed the target?					
Group	0.01	1	0.01	0.02	.902
I/E	0.83	1	0.83	1.00	.320
Group X I/E	0.00	1	0.00	0.01	.941
Error	67.58	82	0.82		
Describe the clarity of the images you used to mentally rehearse gunnery.					
Group	0.02	1	0.02	0.02	.884
I/E	0.93	1	0.93	1.22	.272
Group X I/E	0.32	1	0.32	0.42	.520
Error	62.02	82	0.76		
How effective was mental practice in improving your performance on the ICOFT?					
Group	0.45	1	0.45	0.57	.453
I/E	0.86	1	0.86	1.09	.299
Group X I/E	0.22	1	0.22	0.27	.604
Error	64.05	81	0.79		

Table D-6

Summary of ANOVAs of Performance Data

Performance Measure Source	*SS*	*df*	*MS*	*F*	*p*
Firing Rate					
Group	0.00213	1	0.00213	5.706	.019
Error(b)	0.03210	86	0.00037		
Trial	0.00524	1	0.00524	34.888	<.001
Group X Trial	0.00131	1	0.00131	8.702	.004
Error(w)	0.01293	86	0.00015		
Hit Probability					
Group	0.788	1	0.788	18.280	<.001
Error(b)	3.709	86	0.043		
Trial	2.413	1	2.413	101.763	<.001
Group X Trial	0.349	1	0.349	14.706	<.001
Error(w)	2.039	86	0.024		
Hit Rate					
Group	0.00513	1	0.00513	11.275	.001
Error(b)	0.03913	86	0.00046		
Trial	0.01378	1	0.01378	85.581	<.001
Group X Trial	0.00185	1	0.00185	11.480	.001
Error(w)	0.01385	86	0.00016		

Table D-7

Summary of Protected *T*-tests Between Means of Performance Data

Contrast	*df*	*t*[a]	*p*
	Firing Rate		
Differences Between Groups			
At Pretest	86	3.598	<.001
At Posttest	86	0.436	.664
Differences Between Tests			
For Experimental	86	3.146	.003
For Control	86	9.422	<.001
	Hit Probability		
Differences Between Groups			
At Pretest	86	5.718	<.001
At Posttest	86	1.150	.253
Differences Between Tests			
For Experimental	86	6.651	<.001
For Control	86	14.810	<.001
	Hit Rate		
Differences Between Groups			
At Pretest	86	4.619	<.001
At Posttest	86	1.153	.252
Differences Between Tests			
For Experimental	86	6.238	<.001
For Control	86	13.448	<.001

[a]For comparisons within subjects (i.e., pretest/posttest contrasts), the standard error of the mean was estimated by the within-subject error term from the ANOVA. For comparisons between subjects (i.e., experimental/control contrasts), the standard error of the mean was estimated using a term which pooled within- and between-subject error terms. The significance of the latter effect was estimated using a *t*-approximation method attributed to W. G. Cochran and described in Linquist (1953).

Table D-8

Summary of ANCOVAs of Posttest Performance Data

Performance Measure Source	*SS*	*df*	*MS*	*F*	*p*
Firing Rate					
Group	0.00010	1	0.00010	0.820	.368
Pretest	0.00291	1	0.00291	23.454	<.001
Error	0.01054	85	0.00012		
Hit Probability					
Group	0.00020	1	0.00020	0.015	.903
Pretest	0.15545	1	0.15545	11.903	<.001
Error	1.11005	85	0.01306		
Hit Rate					
Group	0.000062	1	0.000062	0.409	.524
Pretest	0.004498	1	0.004498	29.489	<.001
Error	0.012967	85	0.000152		

Table D-9

Summary of Group by GT Analyses of Gunnery Performance Measures

Performance Measure Source	*SS*	*df*	*MS*	*F*	*p*
Firing Rate					
Group	0.00154	1	0.00154	4.35	.040
GT	0.00204	1	0.00204	5.78	.018
Group X GT	0.00112	1	0.00112	3.15	.079
Error(b)	0.02970	84	0.00035		
Trials	0.00119	1	0.00119	8.17	.005
Group X Trials	0.00039	1	0.00039	2.66	.107
GT X Trials	0.00062	1	0.00062	4.22	.043
Group X GT X Trials	0.00022	1	0.00022	1.53	.219
Error(w)	0.01227	84	0.00015		
Hit Probability					
Group	0.16546	1	0.16546	4.28	.042
GT	0.45755	1	0.45755	11.83	<.001
Group X GT	0.08438	1	0.08438	2.18	.143
Error(b)	3.24793	84	0.03867		
Trials	0.44331	1	0.44331	20.49	<.001
Group X Trials	0.11891	1	0.11891	5.49	.021
GT X Trials	0.20823	1	0.20823	9.62	.003
Group X GT X Trials	0.07191	1	0.07191	3.32	.072
Error(w)	1.81774	84	0.02164		
Hit Rate					
Group	0.00263	1	0.00263	6.35	.014
GT	0.00383	1	0.00383	9.24	.003
Group X GT	0.00177	1	0.00177	4.28	.042
Error(b)	0.03483	84	0.00041		
Trials	0.00216	1	0.00216	14.09	<.001
Group X Trials	0.00051	1	0.00051	3.33	.071
GT X Trials	0.00094	1	0.00094	6.11	.015
Group X GT X Trials	0.00029	1	0.00029	1.88	.174
Error(w)	0.01287	84	0.00015		

Table D-10

Summary of Group by Betts' QMI Analyses of Gunnery Performance Measures

Performance Measure Source	*SS*	*df*	*MS*	*F*	*p*
Firing Rate					
Group	0.00135	1	0.00135	3.94	.050
QMI	0.00124	1	0.00124	3.59	.062
Group X QMI	0.00262	1	0.00262	7.62	.007
Error(b)	0.02791	81	0.00344		
Trials	0.00009	1	0.00009	0.59	.444
Group X Trials	0.00002	1	0.00002	0.18	.668
QMI X Trials	0.00009	1	0.00009	0.58	.447
Group X QMI X Trials	0.00002	1	0.00002	0.14	.713
Error(w)	0.01254	81	0.00015		
Hit Probability					
Group	0.00267	1	0.00267	0.65	.800
QMI	0.20651	1	0.20651	4.99	.028
Group X QMI	0.09044	1	0.09044	2.18	.143
Error(b)	3.35066	81	0.04137		
Trials	0.07607	1	0.07607	3.18	.078
Group X Trials	0.00132	1	0.00132	0.05	.815
QMI X Trials	0.01772	1	0.01772	0.74	.392
Group X QMI X Trials	0.01609	1	0.01609	0.67	.415
Error(w)	1.93980	81	0.02395		
Hit Rate					
Group	0.00112	1	0.00112	2.66	.107
QMI	0.00190	1	0.00190	4.50	.037
Group X QMI	0.00298	1	0.00298	7.07	.009
Error(b)	0.03413	81	0.00042		
Trials	0.00050	1	0.00050	3.04	.085
Group X Trials	0.00002	1	0.00002	0.10	.754
QMI X Trials	0.00008	1	0.00008	0.47	.493
Group X QMI X Trials	0.00006	1	0.00006	0.34	.563
Error(w)	0.01335	81	0.00016		

Table D-11

Summary of Group by Rotter's I/E Analyses of Gunnery Performance Measures

Performance Measure Source	*SS*	*df*	*MS*	*F*	*p*
Firing Rate					
Group	0.00001	1	0.00001	0.02	.875
I/E	0.00018	1	0.00018	0.48	.490
Group X I/E	0.00054	1	0.00054	1.44	.233
Error(b)	0.03153	84	0.00038		
Trials	0.00018	1	0.00018	1.20	.276
Group X Trials	0.00007	1	0.00007	0.46	.502
I/E X Trials	0.00028	1	0.00028	1.83	.180
Group X I/E X Trials	0.00005	1	0.00005	0.30	.585
Error(w)	0.01265	84	0.00015		
Hit Probability					
Group	0.04162	1	0.04162	0.96	.331
I/E	0.04722	1	0.04722	1.09	.300
Group X I/E	0.02640	1	0.02640	0.61	.438
Error(b)	3.65466	84	0.04351		
Trials	0.50262	1	0.50262	20.86	<.001
Group X Trials	0.03914	1	0.03914	1.63	.206
I/E X Trials	0.01023	1	0.01023	0.43	.516
Group X I/E X Trials	0.00145	1	0.00145	0.06	.807
Error(w)	2.01543	84	0.02407		
Hit Rate					
Group	0.00008	1	0.00008	0.17	.677
I/E	0.00007	1	0.00007	0.15	.700
Group X I/E	0.00045	1	0.00045	0.97	.328
Error(b)	0.03869	84	0.00046		
Trials	0.00148	1	0.00148	9.02	.004
Group X Trials	0.00017	1	0.00017	1.04	.310
I/E X Trials	0.00008	1	0.00008	0.47	.494
Group X I/E X Trials	0.00002	1	0.00002	0.12	.733
Error(w)	0.01377	84	0.00016		

Table D-12

Summary of Group by Self-Report Analyses of Hit Probability Data

Performance Measure

Source	*SS*	*df*	*MS*	*F*	*p*
Interaction of Group by Self-Reported Number of Target Destructions					
Group (G)	0.558	1	0.558	13.61	.000
Destructions (D)	0.005	1	0.005	0.12	.731
G X D	0.103	1	0.103	2.50	.117
Error (b)	3.364	82			
Trial (T)	0.922	1	0.922	38.51	<.001
G X T	0.132	1	0.132	5.50	.021
D X T	0.055	1	0.055	2.29	.134
G X D X T	0.005	1	0.005	0.21	.650
Error (w)	1.964	82	0.024		
Interaction of Group by Self-Report of the Clarity of Image					
Group (G)	0.404	1	0.404	9.80	.002
Clarity (C)	0.000	1	0.000	0.00	.982
G X C	0.098	1	0.098	2.39	.126
Error (b)	3.378	82			
Trial (T)	0.624	1	0.624	26.22	<.001
G X T	0.071	1	0.071	2.99	.088
C X T	0.060	1	0.060	2.50	.118
G X C X T	0.001	1	0.001	0.03	.867
Error (w)	1.953	82	0.024		